

The use of casting techniques in foot ulcer treatment: a literature review

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Article points

1. A variety of cast modalities have been developed alongside total contact casting for the treatment of diabetic foot ulcers.
2. Observational studies proved these to be successful interventions.
3. High-quality studies are warranted to validate the efficacy of alternative modalities against the gold standard total contact cast intervention.

Key words

- Casting modalities
- Critical review
- Offloading
- Total contact cast

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Total contact casts are the gold standard offloading option in the treatment of diabetic foot ulcers, but they are underutilised in practice and other modalities have been developed to improve the use of offloading in this patient group. This literature review assessed the efficacy of all casting modalities and their place within standards and guidelines. Data were collected from 64 eligible papers. Data extraction revealed five common topics that formed the basis of data analysis. All topics/categories (efficacy; complications; application processes and healthcare professionals; global utilisation; and guidelines and reviews on casting) were interlinked. Randomised controlled trials support the use of total contact casts and, thus, they are recommended in best practice guidelines, while only observational studies support the use of alternative casting methods. High-quality and head-to-head studies are needed to validate alternative modalities.

Total contact casts (TCCs) are the gold standard offloading option for the treatment of neuropathic diabetic foot ulcers (DFUs). Although evidence in the literature continues to support the efficacy of TCCs as the optimum option for offloading and expediting the healing process, in reality they are very minimally used (Prompers et al, 2008; Wu et al, 2008). As a result, several cast modalities have been developed to facilitate the use of offloading for the treatment of DFUs. This literature review explored the evidence relating to the efficacy of different casting modalities alongside TCCs. It also investigated the recommendations for cast application for DFU management in established standards and consensus documents.

The role of offloading in healing

Biomechanical offloading is a fundamental component of the DFU treatment pathway (Armstrong and Wu, 2005). It is usually carried out in collaboration with the multidisciplinary team, which should ideally consist of podiatrists, diabetes specialist nurses, orthotists, vascular and orthopaedic surgeons, alongside other clinicians or social workers

to provide comprehensive care for patients with DFUs to aid optimal healing and maximise limb salvage (Wounds International, 2013). In the UK, 135 amputations are performed on patients with diabetes every week; diabetic foot ulceration is a precursor to amputation in 84% of these cases (Berrington and Gooday, 2016), therefore, ulceration urgently needs to be addressed to limit the associated social and economic costs (Wu et al, 2005).

Inadequate DFU treatment leads to unnecessarily extended healing times and complications that are otherwise avoidable (Cavanagh et al, 2005). A number of reasons have been identified for the underutilisation of TCCs in clinics. These can be categorised into patient and clinician factors. Patients may be deterred from using TCCs due to their cosmetic appearance, because they limit mobility or because they have concerns about safety. Clinicians require skills and training if they are to efficiently apply TCCs. Clinicians have also voiced concerns about the difficulties involved in inspecting wounds with irremovable devices (Raspovic and Landorf, 2014). These factors have led to modifications to the TCC offloading technique, including the use

Page points

1. Several casting modalities were identified and searched
2. A total of 64 papers were included in this review
3. Two outcomes were investigated: healing and plantar pressures



Figure 1. The Beagle Bohler walker with open-toed fibreglass total contact cast.

of alternative materials, different cast application processes and cast designs. Recently, additional attachments have been added to casts with the aim of enhancing their offloading properties (Figure 1).

Methodology

A systematic literature search of five databases (Medline, Embase, CINAHL, AMED and the Cochrane Library) was carried out to identify publications addressing the following objectives:

- To identify the different modalities available within the casting category of offloading devices and investigate their efficacy
- To evaluate the utilisation of casting modalities as standard clinical practice.

The primary outcome measure was healing. This was a broad term that was broken down into three specific outcomes:

- Healing rate (i.e. time taken to heal)
- Decrease in wound size
- Reduction of exudate levels.

The secondary outcome measure was plantar pressures as it remains one of the main contributors to healing of DFUs (Jeffcoate and Harding, 2003).

The keywords used in the search broadly considered diabetes in association with wounds or ulcers; however, the casting category of offloading was specified and broken down into the different modalities available (Table 1).

Studies comparing TCCs to other offloading interventions were included in this review to discover the validity of TCCs as the gold standard technique for management of DFUs. Studies that involved the different types of offloading casts were also included. In addition, any standards, evidence-based guidelines and consensus documents that were uncovered in the literature search were also included. The studies specifically addressed diabetic foot ulcers. The exclusion criteria included studies that were not in English language, adjunctive therapies and other diabetic foot complications, such as Charcot neuroarthropathy and osteomyelitis or foot infections. Podiatry related studies that evaluated the efficacy of combining dressings with TCCs were also excluded. A data extraction table was used to aid logical critical appraisal of the findings.

Results

The database searches yielded a total of 829 papers. These were narrowed down to a total of 64 eligible papers that were included in this critical review. Eligible documents were divided into three categories: studies, guidelines and reviews. Based on the objectives, data relating to evidence from trials, studies and practice-based guidelines were extracted. The studies included provided insight into where TCCs and other types of offloading casts are employed around the world. Issues and complications involved with TCCs and other casting modalities were identified.

The data extraction table revealed common topics. Five categories were established for critical evaluation based these topics:

- Efficacy of casting modalities
- Complications of casting modalities
- Application processes and healthcare professionals (HCPs)
- Utilisation of casting and the global perspective
- Guidelines and reviews on casting.

The first four categories included data from 37 studies, while the last category comprised of 27 documents solely focussed on reviews and guidelines. Papers included in the 'guidelines and reviews on casting' category identify best practice based on evidence from studies and aim to aid implementation in clinical practice in order to achieve optimum outcomes for people with DFUs.

Discussion

The five categories explored critical matters of concern in DFU management. All were found to be interlinked; issues in one category could have an impact on the findings of other categories. Evidence gaps existed in all of the categories, primarily relating to alternative casting modalities, which have been found effective in observational studies but have not been assessed in randomised controlled trials.

Efficacy of casting modalities

The efficacy of TCCs has been well documented (Sinacore et al, 1987; Armstrong et al, 2001) and established as the gold standard treatment for offloading DFUs, as indicated through the inclusion of TCCs in evidence-based guidelines (Bakker et al, 2016). Randomised controlled trials of TCCs have provided high-quality evidence to support their efficacy in DFU management.

Five alternative casting modalities for DFU management were identified by the literature search alongside previous background research (*Box 1*). The instant TCC (iTCC) and Scotchcast boot were the only two modalities compared to the gold standard TCC (Piaggese et al, 2007; Miyan et al, 2014; Begg et al, 2016). The Scotchcast boot was compared to the TCC in a separate study and the same was done with the iTCC (compared to TCC in a separate study) so each modality was found to be equally effective to the TCC.

More studies are, therefore, warranted to investigate the efficacy of different casting modalities in comparison to TCCs.

There were only four studies in which plantar pressure was a main outcome (Lavery et al, 1996; 2017; Burns and Begg, 2011; Begg et al, 2016). Begg et al (2016) identified an increased plantar load in boot casts when the walls of TCCs were removed.

The two studies by Lavery et al (1996; 1997) were undertaken to investigate plantar pressures at the

ulcer site. However, the study in 1996 evaluated an alternative offloading device, rather than validating the pressure reduction by TCC. It concluded that since no differences were reported between the two offloading modalities, the walker should be considered as an alternative offloading option to TCC. The study in 1997 compared TCC with cast boot or cast heel where it was found that both have the same effect at reducing pressure under the great toe and first metatarsal head, while the cast heel was more effective for the four consecutive metatarsal heads. This again did not clarify the concept behind uniform pressure distribution across the foot. Burns and Begg (2011) evaluated two TCC modalities comparing the conventional TCC to a cushion-modified TCC that incorporated extra padding. The study favoured the modified TCC in terms of greater pressure reduction, however, a recommendation of future studies was reported in order to further evaluate the efficacy of this modality.

Ulcer location is a factor that should be considered when assessing the efficacy of casting modalities. Most studies of TCC efficacy involved participants with forefoot ulcers. For studies that stated the location of the ulcers, all eight studies that included TCCs as the offloading intervention involved patients with forefoot ulcers with some being specified under the metatarsal heads (Mueller and Diamond, 1988; Birke et al, 1991; Lavery et al, 1996; 1997; 2015; Piaggese et al, 2007; Faglia et al, 2010; Begg et al, 2016).

The studies of Bohler's iron and focused rigidity cast (FRC) included patients with DFUs located on either the mid- or hindfoot (Tamir et al, 2007; Malone et al, 2011; Jeffcoate et al, 2014; Barker et al, 2016). None of these modalities have been compared to the TCC. The differences in ulcer location limit the generalisability of the study results for all modalities. Different modalities may lead to better outcomes for ulcers in different areas and evaluation of this could inform clinical practice and lead to the establishment of guidelines that include novel treatments.

Complications of casting modalities

Complications can arise with any casting modality. Two studies evaluated complication rates with the use of TCCs. Wukich and Motko (2004) reported a complication rate of 17% and Guyton (2005),

Box 1. Casting modalities identified.

- Total contact cast
- Instant total contact cast
- TCC-EZ™
- Scotchcast boot
- Focused rigidity cast
- Bohler's iron device

“Guidelines are needed on minimal levels of training and competencies to ensure the safe and effective delivery of offloading interventions.”

Table 1. Keyword search for literature review (example for Medline database) with Boolean operators in red.				
"diabet*"	AND	"foot" N/2 wound*	AND	"offload*"
		"foot N/2 ulcer*		"total contact" N/2 cast*
				"sarmiento"
				"bohler*"
				"scotchcast boot"
				"bivalve*" N/2 cast*
				"instant total contact cast*"
				"PTB" N/2 cast*
				"TCC-EZ"
				"focused rigidity cast*"
				"irremovable cast*"
				"window*" N/2 cast*
				"plaster" N/2 cast*
		OR		OR

whose study included a much larger sample size, found a complication rate of 5.5% per cast. The authors of these studies reported that complication rates could be reduced by frequent inspection and changing casts as necessary, in addition to appropriate cast application.

The use of different cast materials may also reduce the likelihood of complications. Studies into the use of different cast materials and offloading modalities reported no complications associated with the use of fibreglass or Bohler’s iron (Caravaggi et al, 2000; Saikia et al, 2016). Further analysis of different cast materials is needed.

Application processes and healthcare professionals

Data analysis established that a variety of HCPs are involved in the cast application process; however, professional knowledge of foot biomechanics remains in question. It is important that HCPs have sufficient knowledge of foot biomechanics as they need to understand and apply the concept of uniform pressure distribution across the plantar surface of the foot as well as preventing secondary ulcerations on bony prominences resulting from

malalignment of the foot within the cast. Sinacore and colleagues (2001) stated that overpronation can occur if the ankle is forced into the desired 90° position for casting, resulting in prominences of the medially-located bones of the foot, in particular the talus and navicular. These bony prominences present areas of high pressure within the cast and can lead to complications such as skin irritation. It would be useful to survey HCPs involved in casting to determine their knowledge of foot biomechanics. This would aid with clarification of which HCPs should be present in the multidisciplinary DFU management team. It would also enable the identification of training needs and assessment of the efficacy of any training provided.

Utilisation of casting and the global perspective

The studies exploring the percentage utilisation of casting modalities, in particular TCCs, all suggested that these modes of treatment are underutilised by HCPs in diabetic foot clinics (Prompers et al, 2008; Wu et al, 2008; Fife et al, 2014; Raspovic and Landorf, 2014; Quinton et al, 2015). Underutilisation was related to barriers posed by

TCCs. Four types of barriers were identified: patient, practitioner, wound and intervention-associated barriers (Raspovic and Landorf, 2014). These can all strongly impact the utilisation of TCCs and other casting modalities in clinics.

The casting modalities investigated in the literature were TCC, iTCC and TCC-EZ (Prompers et al, 2008; Wu et al, 2008; Fife et al, 2014; Raspovic and Landorf, 2014; Quinton et al, 2015). The other casting modalities were neglected, implying that they may not be well known to clinicians and diabetic foot centres. Knowledge of different casting modalities could be further investigated by surveying HCPs.

Internationally, the lowest proportion of studies included in the literature review came from Asian and African countries. This may reflect of a lack of the required expertise for cast application. However, it is important point to note that these countries might lack financial resources, thus the cost of casting materials might present an issue. An investigation of cheaper alternatives for poorer countries was recommended by Miyan et al (2014).

Guidelines and reviews on casting

A total of 27 publications, including several guidelines, systematic reviews and critical/narrative reviews, analysed and reported on the efficacy of cast interventions on DFU management. These documents aimed to create a bridge between evidence-based theory and clinical practice (Bus, 2012). TCC was the main casting modality featured in the literature, and its use is recommended in guidelines (Bus et al, 2016). Guidelines currently only recommend one alternative casting modality (iTCC) as an alternative to TCC. Recommendations have been made to investigate other modalities, such as the novel FRCs or Bohler's iron for more proximal lesions.

Jeffcoate et al (2008) highlighted the need for guidelines on minimal levels of HCP training and competencies to ensure the effective and safe delivery of offloading interventions. This is critical for casting modalities, as it has implications for the risk of complications, levels of utilisation and global application. Berrington and Gooday (2016) speculated that there would be an increase in the utilisation of offloading devices if training was given to clinicians involved in the biomechanical aspects of DFU management.

The British Orthopaedic Association's (2015) national casting standards, which are mainly aimed at orthopaedic practitioners, document the competencies required by HCPs. To implement casting methods, HCPs in the UK must be hold a British Casting Certificate. Although the UK standards mainly relate to orthopaedic conditions such as fractures, these HCPs have the appropriate skills for cast application for the management of DFUs.

Cast application techniques continue to evolve based on the application of clinical judgement, the development of skills and expertise, for example the application of an open-toed as opposed to closed-toe cast (Ciona et al, 2014). Knowledge of the modifications is useful when establishing best practice for cast application. Collaboration between national/international best practice groups and the bodies producing training standards for cast application will lead to a cohesive approach that will encourage the utilisation of casting for the management of DFUs within the clinical setting.

Costs: an additional consideration

The main aim of DFU management is healing and ultimately limb salvage (Shishir, 2012). This review focused on healing, patient- and HCP-related factors that may impact on cast use/efficacy. However, cost is an important consideration. The economic benefits of limb salvage are significantly greater than the costs associated with amputation (Wu et al, 2005). Cost savings will ultimately be achieved by prescribing suitable and effective offloading to promote faster healing of DFUs. This will benefit both the service provider and the patient.

Conclusion

The efficacy of TCCs has been established through high-quality evidence and TCCs are therefore recommended in practice-based guidelines. Five alternative casting modalities have been assessed by observational studies but not randomised controlled trials, therefore further research is warranted to validate their efficacy against the gold standard intervention.

Guidelines currently lack information on the minimum training and competencies required for optimum care delivery. Training may remove some barriers to the application of casting techniques in practice. ■

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